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THE UNIVERSITY OF TENNESSEE

DEPARTMENT OF ELECTRICAL ENGINEERING

DEVELOPMENT OF A HIGH FREQUENCY STEERABLE ANTENNA

INTERIM DEVELOPMENT REPORT NO. 16

10 January 1954

Navy Department — Bureau of Ships
Electronics Divisions
Contract No. NObsr-57448 Index No. NE-091035 ST7

A PROJECT OF THE ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE COLLEGE OF ENGINEERING
Knoxville, Tennessee

INTERIM DEVELOPMENT REPORT

FOR

DEVELOPMENT OF A HIGH FREQUENCY

STEERABLE ANTENNA

This report covers the period
1 December 1953 to 31 December 1953

ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE

Navy Department — Bureau of Ships
Electronics Divisions
Contract No. NObsr-57448 — Index No. NE-091035 ST7

10 January 1954

Copy No. 4

ABSTRACT

This report covers work done on Contract No. Nobsr-57448, Index No. NE-091035 ST7, at The University of Tennessee during the month of December, 1953.

The following was accomplished:

1. The design of vertically stacked rhombics to cover the frequency range of 4 to 32 megacycles was started.

2. The problem of determining a satisfactory broadband termination for the circular traveling wave antenna continued to receive attention.

3. The radiation pattern was calculated for a vertical half-rhombic antenna above a perfectly conducting ground for the case in which the phase velocity along the rear leg is one-half that along the front leg.

PART I

Purpose

This project involves the development of a high frequency steerable antenna having the following characteristics:

1. It shall be operable throughout the frequency range of 4 to 32 megacycles per second.

2. It shall be capable of four, or more, simultaneous transmissions on different frequencies, and at different azimuth and elevation angles.

3. For each transmission, it shall be capable of being directed to any azimuth angle and to any elevation angle between the horizon and 30° above the horizon.

The communication system shall provide reliable 24-hour day-to-day communication with a 20 decibel signal-to-noise ratio. The ranges to be covered are from approximately 500 nautical miles to 4000 nautical miles.

The development consists of two phases:

Phase I. Theoretical and experimental studies.

Phase II. Development of design criteria.

General Factual Data

Personnel:

F. V. Schultz	Project Director	58 1/2	Man-hours
W. E. Lear	Associate Engineer	40	Man-hours
W. J. Bergman	Junior Engineer	168	Man-hours
H. P. Neff	Junior Engineer	88	Man-hours
G. R. Turner	Secy-Draftsman	73	Man-hours
L. Phillips	Technician	88	Man-hours
R. F. Bunn	Student Computer	12 1/2	Man-hours
H. Knox	Student Computer	41 1/2	Man-hours
L. Zollinger	Student Technician	26 1/2	Man-hours
Alma Rich	Secretary	1	Man-hours

References

Andrew Alford, Consulting Engineers, "Directional Ground Antenna Arrays with Beam Steerable in Azimuth for Operational Communication Tests of Aircraft Equipment," Contract No. W33(038)-17512, February 1952.

Bruce, E., and Beck, A. C., "Experiments with Directivity Steering for Fading Reduction," Bell System Technical Journal, Vol. 14, p. 195, April 1935.

Foster, Donald, "Radiation from Rhombic Antennas," Proceedings of the Institute of Radio Engineers, Vol. 25, p. 1327, October 1937.

Harper, A. E., Rhombic Antenna Design, D. Van Nostrand Co., Inc., New York, 1941.

Harrison, C. W., "Radiation from Vee Antennas," Proceedings of the Institute of Radio Engineers, Vol. 31, p. 362, July 1943.

Jordan, E. C., Electromagnetic Waves and Radiation Systems, Prentice Hall, Inc., New York, 1950.

Kraus, J. D., Antennas, McGraw-Hill Book Company, 1950.

Marchand, N., Ultrahigh Frequency Transmission and Radiation, John Wiley and Sons, Inc., New York, 1947.

Radio Research Laboratory, Harvard University, Very High-Frequency Techniques, Vol. I, McGraw-Hill Book Co., Inc., New York and London, 1947.

Terman, F. E., Radio Engineers' Handbook, McGraw-Hill Book Co., New York and London, 1943.

Williams, H. P., Antenna Theory and Design, Pitman and Sons, Ltd., London, 1950.

Detail Factual Data

1. The design of vertically stacked rhombics to cover the frequency range of 4 to 32 megacycles was started. Due to the fact, however, that the responsible engineer was on vacation for a large portion of the month, progress on this part of the project was not sufficient to warrant the reporting of the results obtained.

2. Transmission lines designed to have characteristic impedances of 800, 600, 500, and 400 ohms have been constructed, using nichrome wire, for use as terminations for the circular traveling wave antenna. These lines were designed to have sufficiently high attenuation so as to appear infinitely long. The 800, 600, and 400 ohm lines were built using 0.001 inch diameter nichrome wire, and lengths of approximately 100 cm produce sufficient attenuation. However, this wire is so small and fragile that it is practically impossible to make good electrical connections to the antenna. The 500 ohm line was made using size 40 nichrome, and although seven feet of line was required to obtain sufficient attenuation, it is easily connected to the antenna.

The commercial balun has been received, and is being used for making impedance measurements, as well as for supplying balanced energy to the antenna from an unbalanced source.

A new antenna has been constructed with a circumference of 5λ at 1000 Mc, and standing wave patterns on the antenna have been taken, using the 500 ohm line as the antenna termination, at frequencies of 800, 1000, and 1200 Mc. The antenna circumference is 4λ at 800 Mc, and 6λ at 1200 Mc. The standing wave ratio varies slightly at the three different frequencies but does not exceed a ratio of 1.8.

The impedance of the 500 ohm line was measured at each frequency and remains substantially the same at a value slightly less than 500 ohms.

Refinement and standardization of the measuring techniques and construction practices are necessary before conclusive results will be obtained.

3. The radiation pattern was calculated for a vertical half-rhombic antenna above a perfectly conducting ground for the case in which the phase velocity along the rear leg is one-half that along the front leg. This was an exploratory effort made in order to obtain some idea of the effectiveness of this procedure in tilting the beam vertically. Since the calculations have not been checked the results are not presented herein.

DEPARTMENT OF ELECTRICAL ENGINEERING - ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE

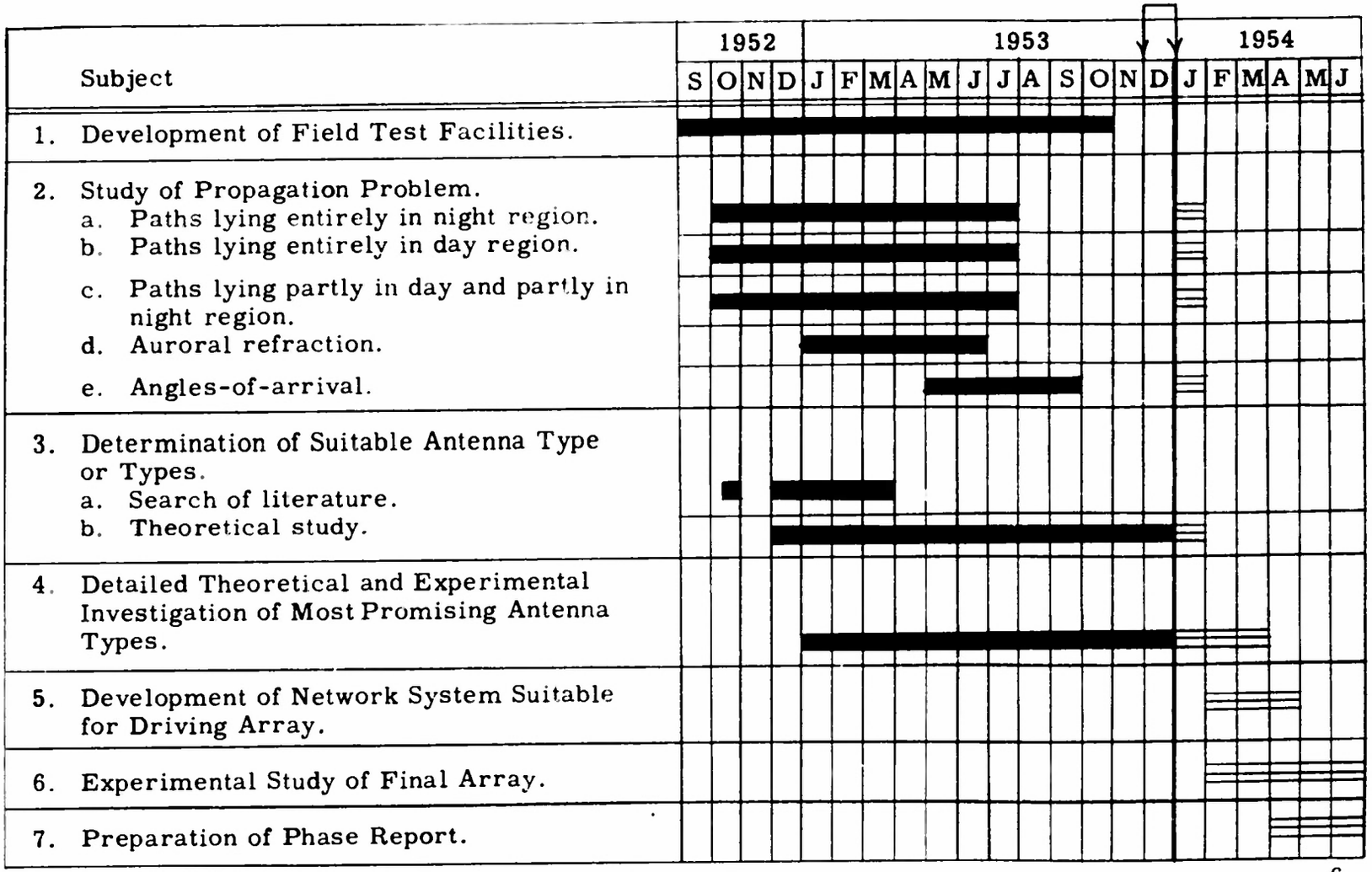
PROJECT PERFORMANCE AND SCHEDULE

Contract No. NObsr-57448 Index No. NE-091035 ST7 Date: 10 January 1954

Legend: Work Performed

Schedule of Projected Operation

Period Covered: 1/12/53 to 31/12/53



Conclusions

None.

PART II

Program for Next Interval

1. The design of vertically stacked rhombics to cover the frequency range of 4 to 32 megacycles will be continued.